

ESA PREPARING FOR THE FUTURE ACT PRO

[More information](#)[ESA > ACT > Advanced Propulsion](#)[About us](#)

[The team](#)
[Who we are](#)
[Who we were](#)

[Ariadna](#)

[About Ariadna](#)
[Search studies](#)
[Ariadna Calls](#)
[FAQ](#)

[Publications](#)

[ACT papers](#)
[Acta Futura](#)

[Other](#)

[Research Vacancies](#)
[Events](#)

INERTIAL ELECTROSTATIC CONFINEMENT THRUSTERS**Inertial Electrostatic Confinement Thrusters**

In concentrically aligned electrode grids ions are accelerated towards the center where they collide with other ions coming from other directions. From the plasma core highly energetic charges can be extracted to form a plasma jet.

Inertial Electrostatic Confinement (IEC) devices were originally developed and used for fusion research purposes [1]. Those had a spherical geometry, but cylindrically design IEC devices have been commercialised already [2]. The simplest IEC type of set-up contains a spherical cathode grid, which is co-centrally placed within in a spherical anode. The cathode, made of stainless steel wires, is negatively charged (typically several kV) while the anode is grounded. The vacuum chamber contains a highly rarefied neutral gas with a pressure matched to the electrode distance in order to provide a glow discharge. The produced ions are accelerated by radial electric fields towards the centre of the sphere where they collide with other ions building a positively charged ion cloud. This ion cloud itself accelerates electrons towards the centre of the sphere which can lead to the creation of a virtual cathode. Due to an effect called micro-channelling the ions are pushed away from the grid wires such that the effective grid transparency can exceed 95% [3]. An in-depth description of the working principle and the physics of the IEC confinement can be found in [1, 3, 4] and references therein. It has been shown recently (see e.g. [5, 6]) that it is possible to extract a plasma jet from the confinement. The jet was obtained by creating in both grids an opening in the confinement, i.e. the grid openings were locally enlarged in order to provide a lower potential barrier for the confined charges to escape. The extraction has been experimentally observed though its properties, working mechanism, key parameters are still not well understood. Depending on the literature, the creation of a quasi-neutral beam is described as a consequence of initially escaping electrons from the confinement. Those electrons induce strong electric fields, thereby attracting and accelerating confined ions such that both species form a particle jet. In order to keep the operation steady neutrals are added according to the extracted plasma mass flow. IEC reactors in jet mode would thus be, in principle, usable for propulsion purposes. In fact, specific impulses of up to 4000s were estimated in [7]. While such devices have been proposed as space thrusters, arguing that - the life time is increased due to a larger grid transparency, - the set-up is simple and of low weight, - it scales well with power, - exhaust plasma modifications are possible to provide fast manoeuvrability, and that - efficiency and thrust are good, the mechanisms are still poorly understood as a comprehensive theoretical model of the underlying jet extraction physics is still lacking.

Current IEC research at ACT focuses on two main aspects: system level modelling of a spherical IEC in non-jet mode and kinetic modelling of the spherical IEC thruster including fusion processes. The latter aims not only for fundamental understanding of the jet extraction mechanism, but also for finding a mode of operation which justifies the IEC to be driven in fusion and jet mode.

References

- [1] W. C. Elmore, J. L. Tuck, K. M. Watson, "On the Inertial-Electrostatic Confinement of a Plasma", *Physics of Fluids* 2, 239 (1959); doi:10.1063/1.1705917.
- [2] J. Sved, N. Menduev, T. Firestone, "Applications for Gas-Plasma Target Neutron Generators", Paper SM/EN-18 presented at the International Topical Meeting on Nuclear Research Applications and Utilization of Accelerators, 4-8 May 2009, Vienna.
- [3] Miley, G. H., Gu, Y., DeMora, J. M., Stubbers, R. A., Hochberg, T. A., Nadler, J. H., Anderl, R. A., "Discharge Characteristics of the Spherical Inertial electrostatic Confinement (IEC) Device", *IEEE Transactions on Plasma Science*, Vol. 25, No. 4, Aug 1997, pp. 733-739.
- [4] T. H. Rider, "A general critique of inertial-electrostatic confinement fusion systems", *Phys. Plasmas* 2 (6), June 1995, 1853-1872.
- [5] G.H. Miley, B.P. Bromley, and Y. Gu, "A Novel IEC Plasma Jet Thruster", *Bulletin of the American Physical Society*, 40:1688, 1995.
- [6] C. C. Dietrich, "Improving Particle Confinement in Inertial Electrostatic Fusion for Spacecraft Power and Propulsion", Phd thesis, MIT, 2007.
- [7] G. H. Miley, H. Momota, L. Wu, M. P. Reilly, V. L. Teofilo, R. Burton, R. Dell, D. Dell, and W. A. Hargus, "IEC Thrusters for Space Probe Applications and Propulsion", *AIP Conf. Proc.* 1103, 164 (2009), DOI:10.1063/1.3115492.

[Search here](#)[Research](#)

- [Advanced Materials](#)
- [Artificial Intelligence](#)
- [Bio-Engineering](#)
- [Biomimetics](#)
- [Computational Management Science](#)
- [Earth System Science](#)
- [Energy Systems](#)
- [Fundamental Physics](#)
- [Informatics](#)
- [Mission Analysis](#)
- [Propulsion](#)

[Follow Us](#)[What is hot ...](#)

[Kelvin's competition website](#)



[Active Debris Removal](#)



[Visualisation of Mars Express Datasets using Immersive Virtual Reality](#)

SHARE THIS PAGE

LATEST ARTICLES

- Deep-space stations gain made-in-E...
- ESA test opens way to UK spaceplan...
- South Pacific Galileo station endu...
- Nature valued from space
- Thales Alenia Space kicks off Eucl...

MOST-VIEWED ARTICLES

- New Images from Titan
- Black hole-star pair orbiting...
- Planck reveals an almost perf...
- How many stars are there in t...
- Reull Vallis: a river ran thr...

MOST-VIEWED IMAGES

- Planck CMB
- Titan's Nile River
- Mapping Mars
- Reull Vallis
- Perspective view of Reull Val...

MOST-VIEWED VIDEOS

- ESA - Space to Relax / Our Co...
- ISS with Space Shuttle "Endea...
- M31 the Andromeda Galaxy
- 50 years of humans in space
- Welcome home, Paolo!

FAQ	JOBS AT ESA	SITE MAP	CONTACTS	TERMS AND CONDITIONS	
-----	-------------	----------	----------	----------------------	--